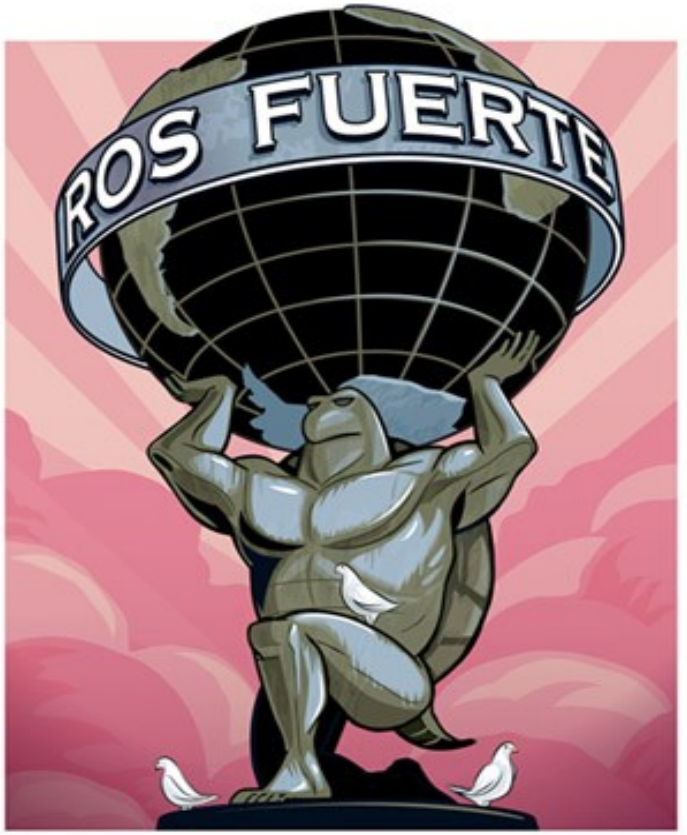
ROS: Tips n' Tricks



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COMP-417, McGill University
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Inspired by presentation of Marek Doniec, MIT

Overview

- What is ROS?
- Features
- Philosophies
- Core elements
- Development pipeline
- Useful ROS nodes / tools

What is ROS?

- Meta operating system (or middleware)
- Features:
  - Message-passing / network abstraction
  - Package management
  - Tools & libraries for obtaining, building, writing, and running code across different computers
- “The primary goal of ROS is to support code *reuse* in robotics research and development.”

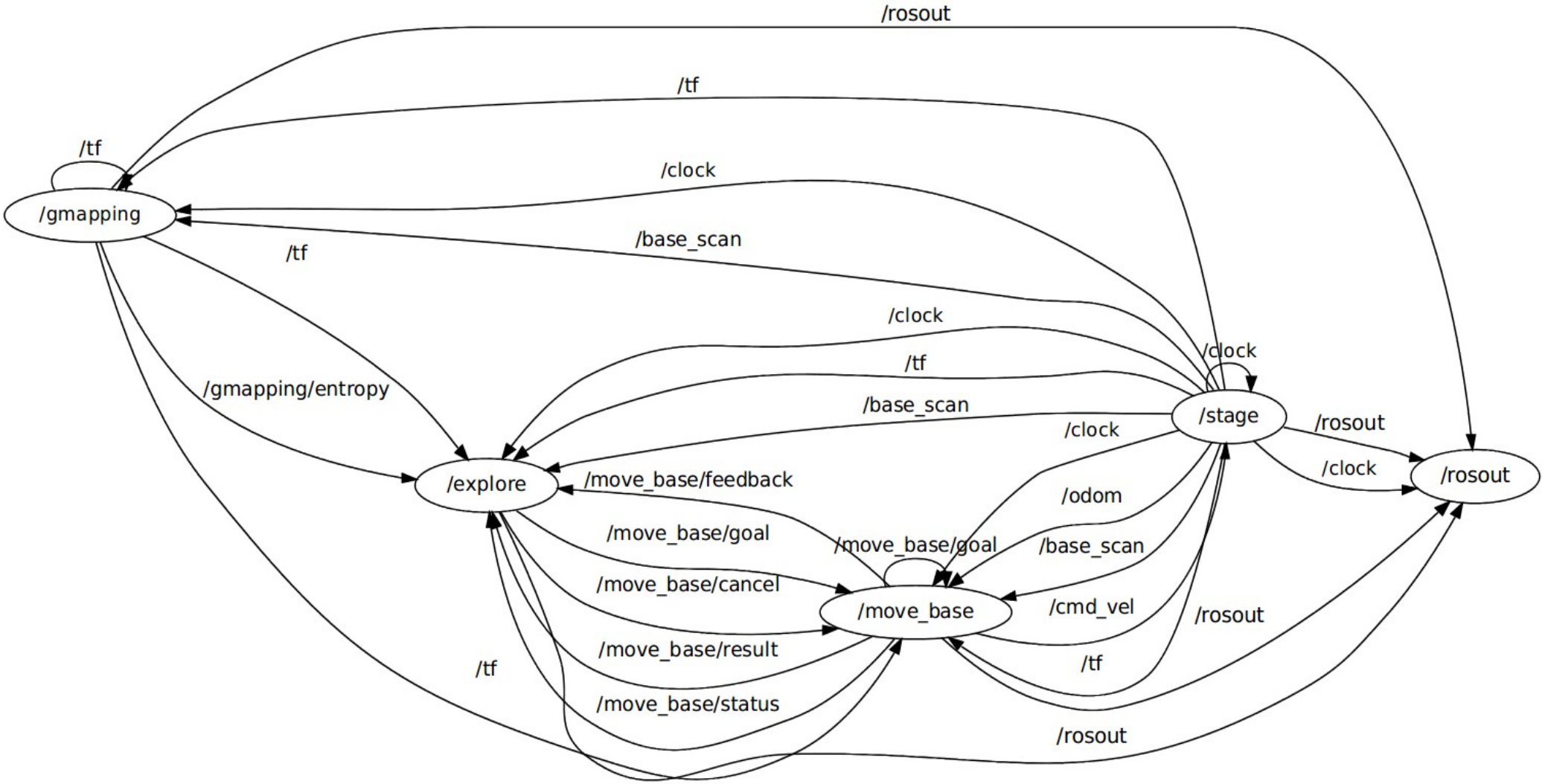
ROS: Features

- Library dependencies
  - Compilation & Linking (via manifest.xml)
  - Non-ROS libraries (via CMake)
- Communication layer
  - Inter-process
  - Inter-machine
- Process management

ROS: Philosophies

- Modular & peer-to-peer
- Language independent
- Thin
- Free & open-source

ROS: Modularity & Peer-to-Peer



ROS: Language Independence

- Client interfaces:
  - Stable: rospy, roscpp, roslisp
  - Experimental: rosjava, roslua
  - Contributed: rosserial, roshask, ipc-bridge (MATLAB), etc...
- Common message-passing layer
  - Interface Definition Language (IDL)

ROS: Thin

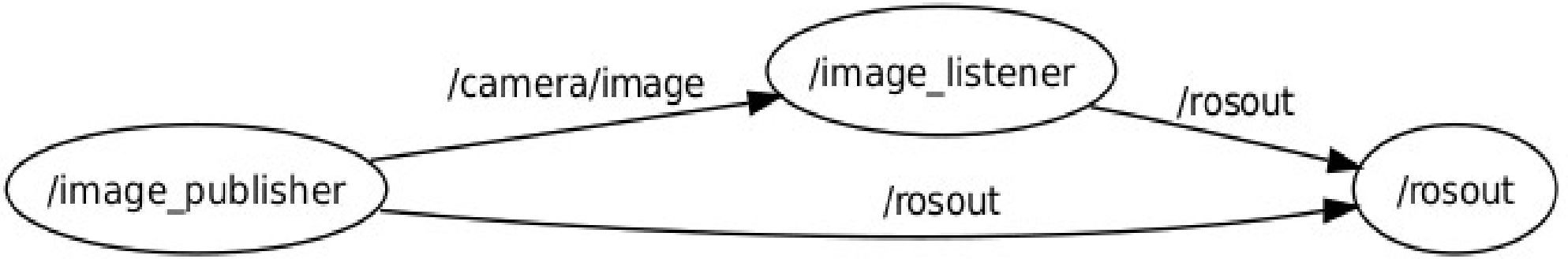
- Library-style interaction
  - Facilitates integration with other common libraries, e.g.: OpenCV, PCL, bullet, etc...
- Minimal dependencies
  - Linked against (lean) ROS core + necessary message meta-libraries + specific libraries
- “The preferred development model is to write ROS-agnostic libraries with clean functional interfaces.”

ROS: Free & Open-Source

- Source code is publicly available
- ROS Core & 1st party tools are under BSD license
- Contributed tools are under a variety of open-source (& closed-source) licenses
- Promotes code-reuse and community-building

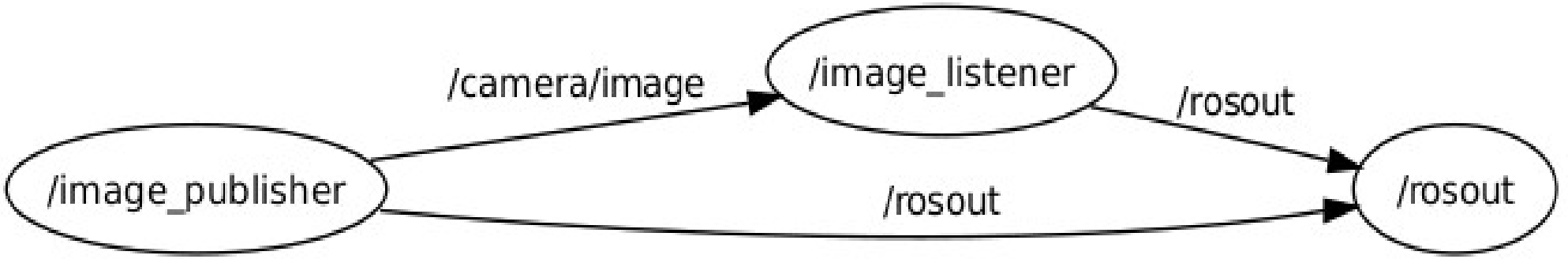
ROS: Core Elements

- Nodes
- Messages, topics, and services
- ROS Master
- Parameters
- Bags



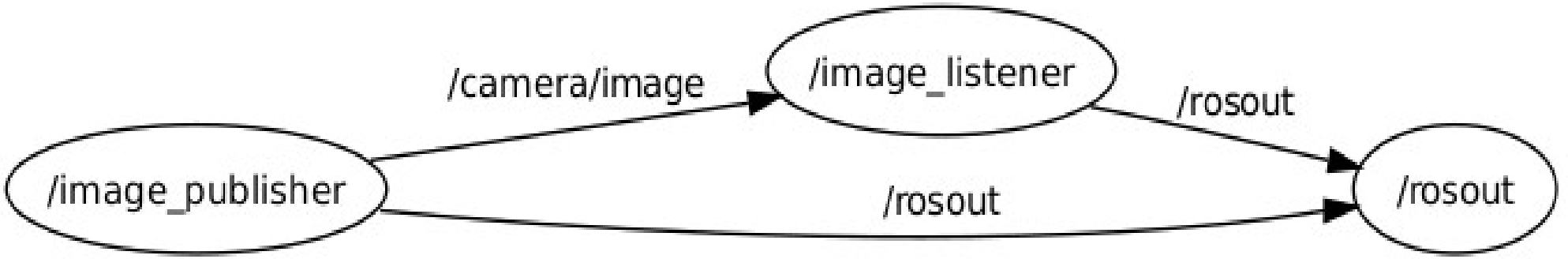
ROS Nodes

- Single-purposed executable programs
  - e.g. sensor driver(s), actuator driver(s), mapper, planner, UI, etc...
- Modular design
  - Individually compiled, executed, and managed
- Nodelets



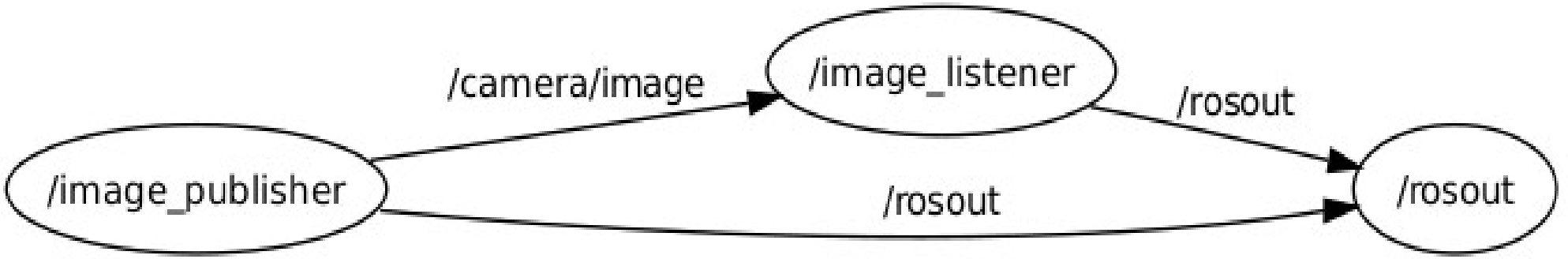
ROS Messages

- Strictly-typed data structures for inter-node communication
- Interface Definition Language (IDL)
  - Basic types: bool, [u]int{8,16,32,64}, float{32/64}, string, time, duration, etc...
  - Arrays
  - Nested messages: image, GPS, IMU, etc...



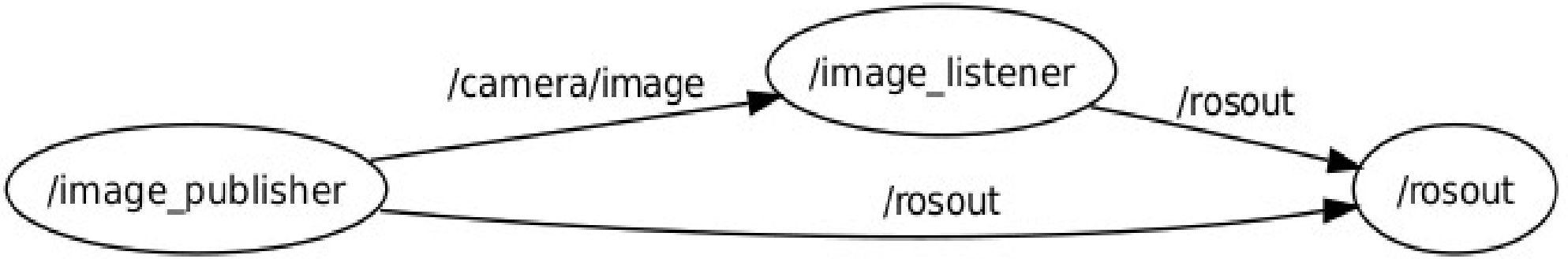
ROS Topics

- Unidirectional (& often repeated) inter-node communication
- Publish/Subscribe model: **M**-to-N broadcasting
- Examples:
  - provide sensor readings
  - provide actuator states / robot feedback



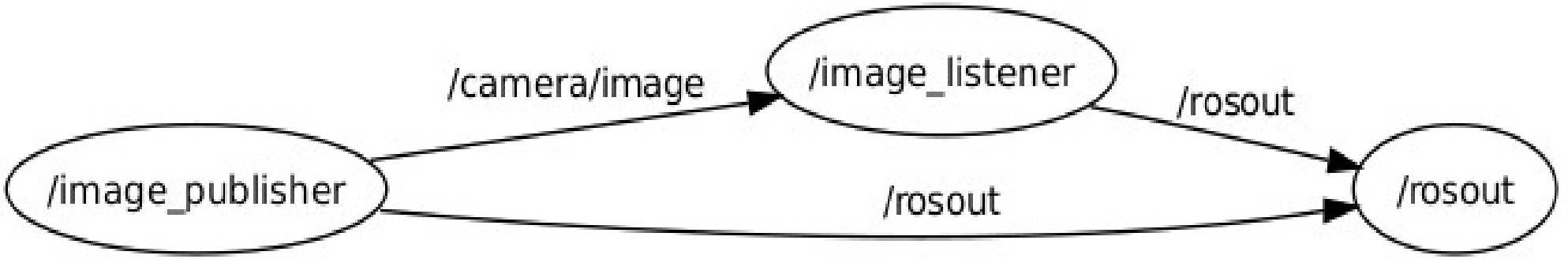
ROS Services

- Synchronous inter-node transactions / RPC
- Service/Client model: 1-to-1 request-response
- Examples:
  - carry out remote computation
  - trigger functionality / behavior
  - (*) dynamically update parameter

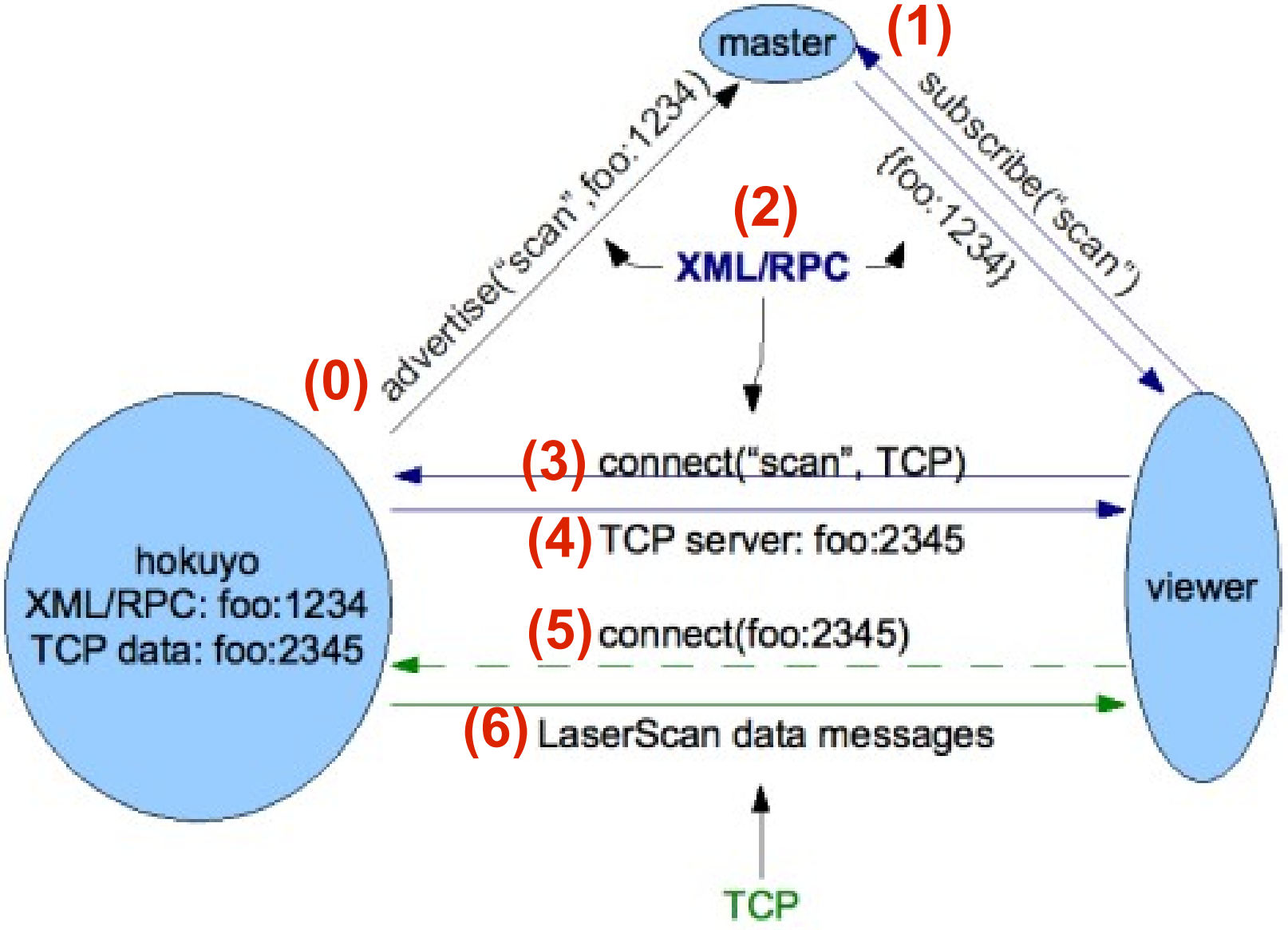


ROS Master

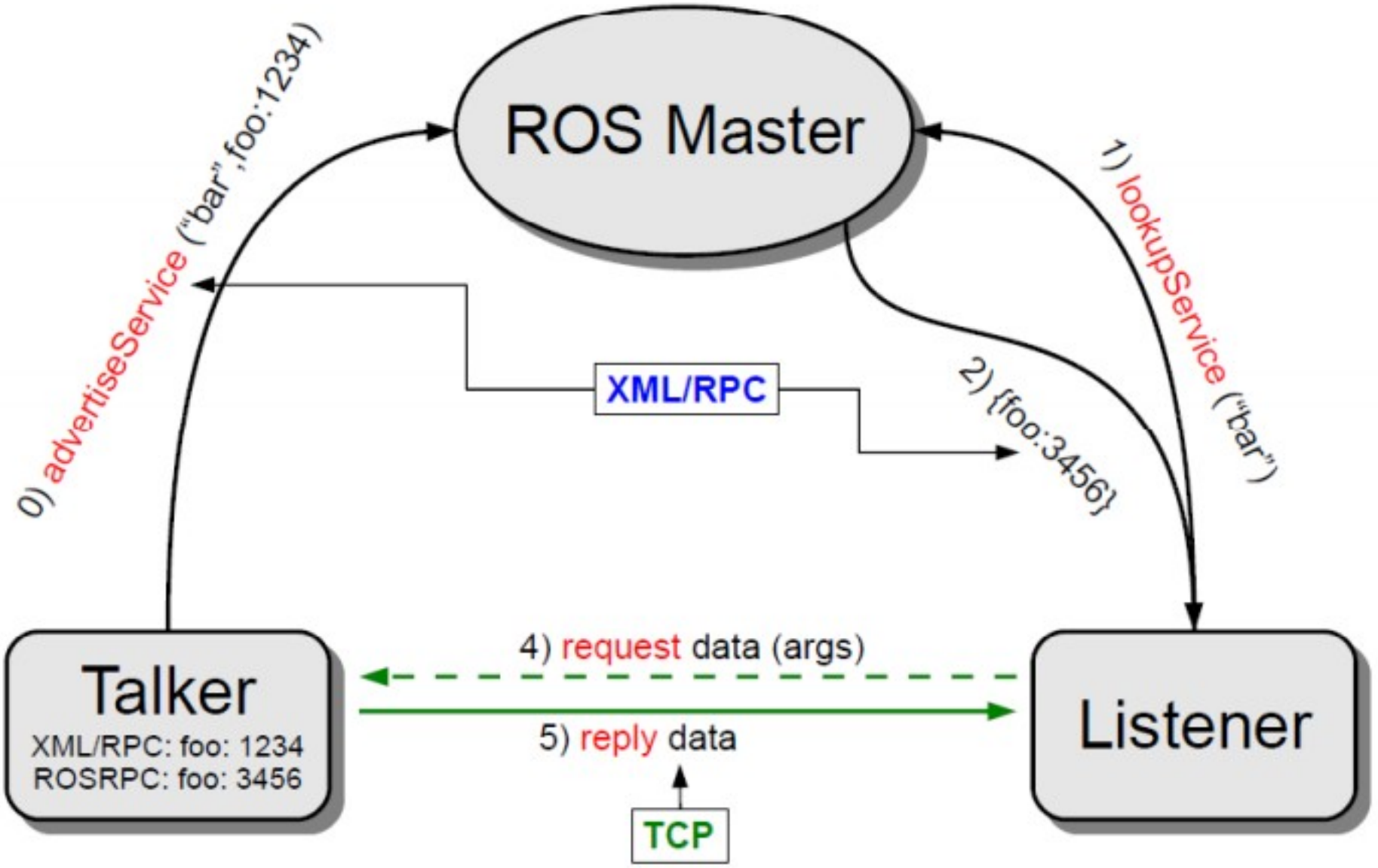
- Naming & registration services for nodes, topics, services, etc...
- “The role of the Master is to enable ROS nodes to locate one another.”
- Critical environment variable:
  - $ROS_MASTER_URI=http://[HOST]:[PORT]



ROS: Topic Subscription

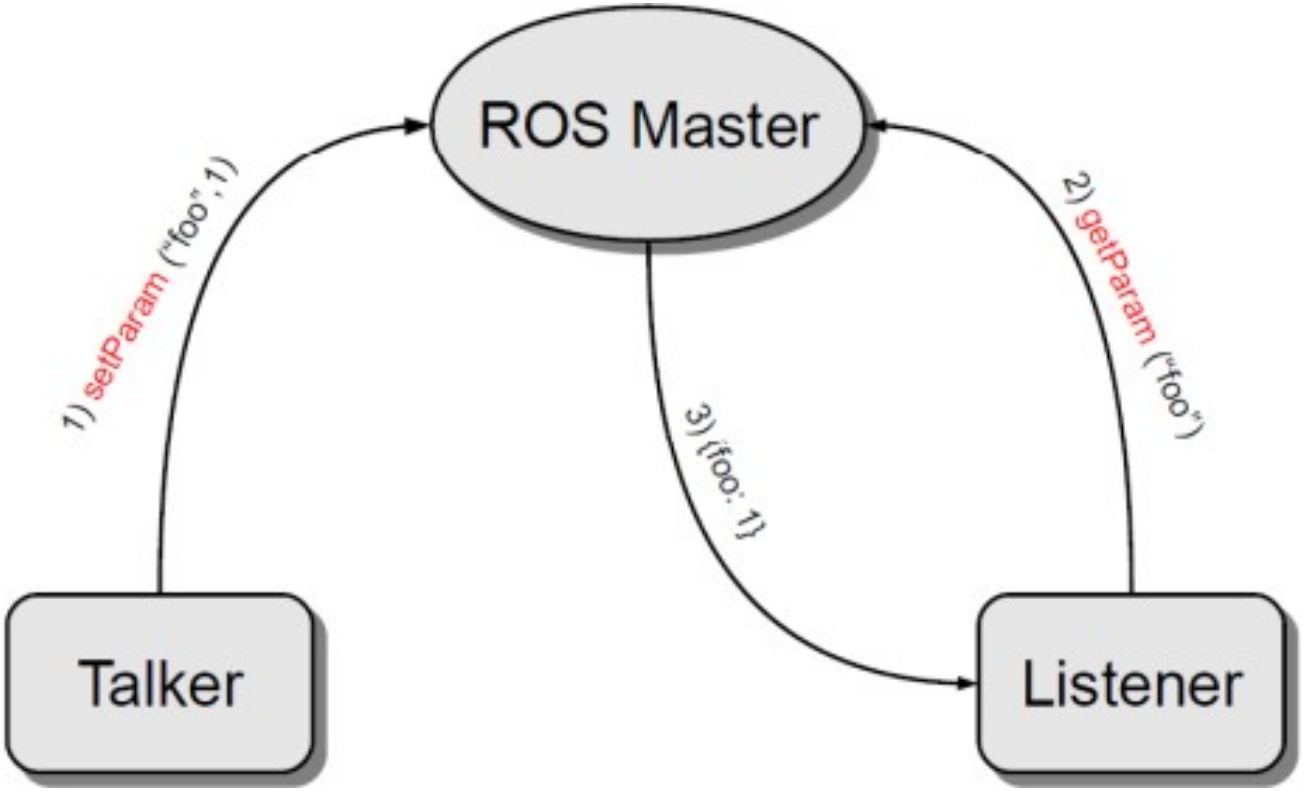


ROS: Service Call



ROS Parameters

- Configurable setting
  - Node-specific
  - Launch-time
- Unique name
- Typed (XMLRPC)
- Can be remapped at runtime

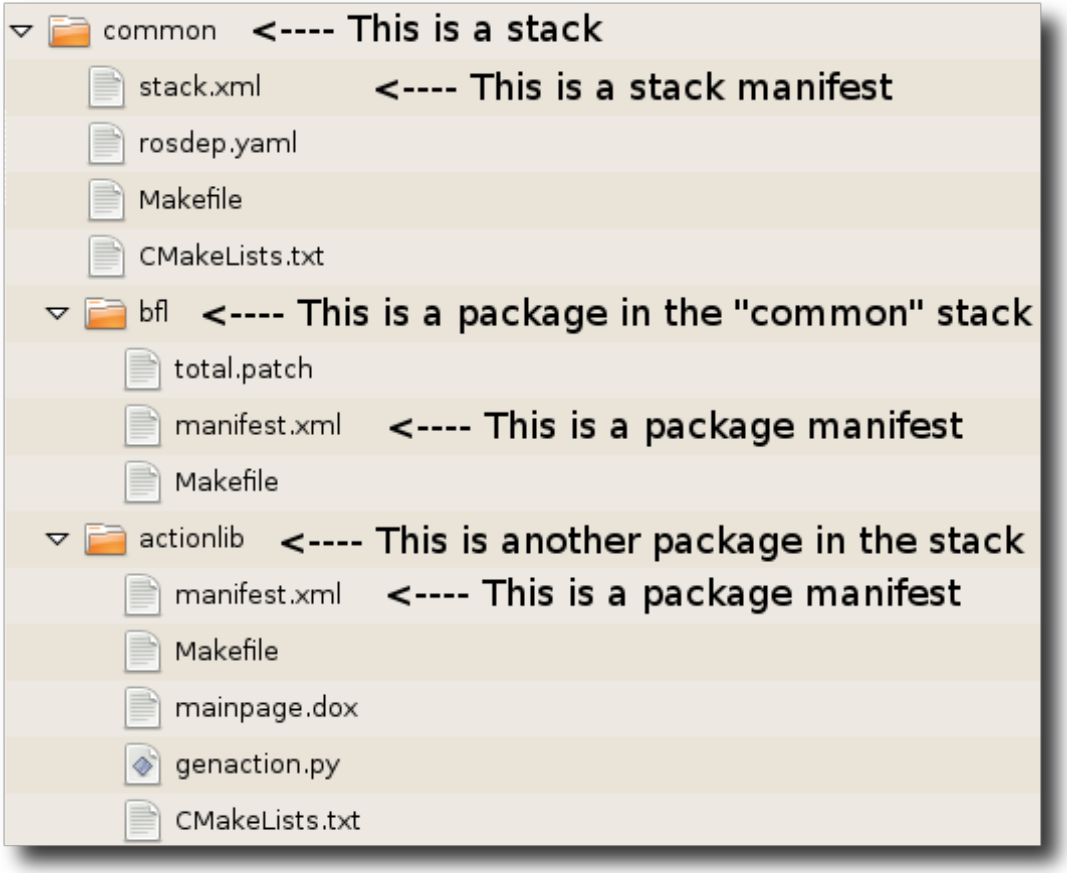


ROS Bags

- Standardized logging & playback mechanism
  - Single-file container for serialized messages
- Playback using simulated / real clock
  - (Near-)realistic message playback

ROS: Packages & Stacks

- Package: nodes, messages, service types, configuration files, etc...
- Stack: collection of packages



ROS Development Pipeline

- Setup: rosws, roscreate-pkg
- Navigate: roscd, rosed
- Configure: manifest.xml, CmakeLists.txt
- Build: rosmake
- Execute: roscore, rosrun, roslaunch, rosparam
- Inspect: rosnode, rostopic, rosservice
- Debug: rostest, roswtf, rqt_graph
- Log & Analyze: rosbag, rqt_bag

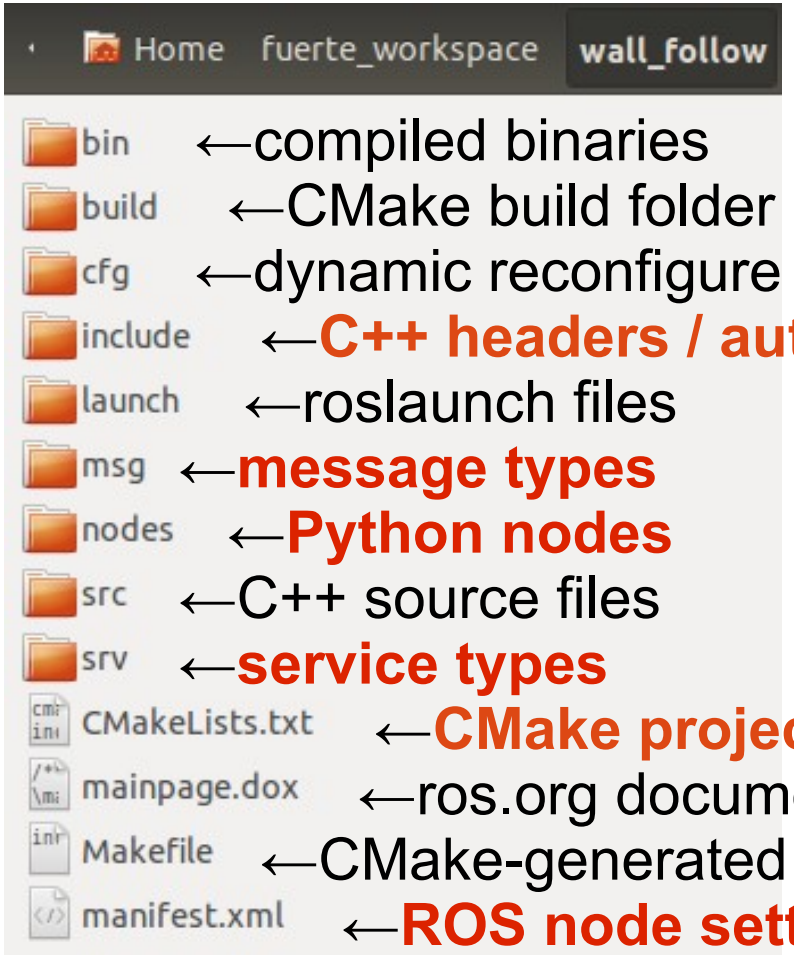
Setup: rosws

- Manages ROS workspace
- Provides standard interface to revisioned code

- rosws init ~/fuerte_workspace /opt/ros/fuerte
- rosws info control_toolbox
- rosws update turtlebot

Setup: roscreate-pkg

- Creates new ROS package
- roscreate-pkg wall_follow rospy sensor_msgs



Navigate: roscd / rosed

- Provides fast navigation to ROS folders / files

- roscd stage
- rosed wall_follow wall_follower.py
- export EDITOR='emacs -nw'

Configure: manifest.xml

- Lists properties and ROS node dependencies

```
<package>
  <description>A simple viewer for ROS image topics.</description>
  <author>Patrick Mihelich</author>
  <license>BSD</license>
  <review status="Doc reviewed" notes="Dec 17, 2009"/>
  <url>http://www.ros.org/wiki/image_view</url>

  <export>
    <cpp cflags="-I${prefix}/include" lflags="-Wl,-rpath,${prefix}/lib -L${prefix}/lib -limage_view" />
    <nodelet plugin="${prefix}/nodelet_plugins.xml" />
  </export>

  <rosdep name="opencv2"/>
  <depend package="cv_bridge"/>
  <depend package="image_transport"/>
  <depend package="nodelet" />
  <depend package="roscpp"/>
  <depend package="sensor_msgs"/>
  <depend package="stereo_msgs"/>
</package>
```

Configure: CMakeLists.txt

- Configures build environment & lists non-ROS dependencies

```
cmake_minimum_required(VERSION 2.4.6)
include($ENV{ROS_ROOT}/core/rosbuild/rosbuild.cmake)
set(ROS_BUILD_TYPE RelWithDebInfo)

rosbuild_init()

set(EXECUTABLE_OUTPUT_PATH ${PROJECT_SOURCE_DIR}/bin)
set(LIBRARY_OUTPUT_PATH ${PROJECT_SOURCE_DIR}/lib)

rosbuild_genmsg()
rosbuild_gensrv()

#rosbuild_add_boost_directories()
#rosbuild_add_library(${PROJECT_NAME} src/example.cpp)
#target_link_libraries(${PROJECT_NAME} another_library)
#rosbuild_link_boost(${PROJECT_NAME} thread)
#rosbuild_add_executable(example examples/example.cpp)
#target_link_libraries(example ${PROJECT_NAME})
```

Build: rosmake

- Builds ROS packages
  - packages with msg/srv must be built, even if they only contain Python nodes

- rosmake wall_follow
- (roscd wall_follow; mkdir build; cd build; cmake ..)

Execute: roscore

- Starts ROS master
  - Only 1 master per machine
  - Can use remote ROS master instead
  - Hostname must be defined in /etc/hosts
- roscore
- export ROS_MASTER_URI=http://remote:11311

Execute: rosrun

- Executes ROS node
  - namespace remappings
  - node-specific parameters (use '--' to delineate)

- rosrun image_view image_view image:=/camera/image_raw -- compressed

Execute: roslaunch

- Executes multiple ROS nodes concurrently
  - Launch files should have .launch extension, to be indexed automatically
  - Initialize ROS Master automatically if needed

- roslaunch image_proc image_proc.launch

```
<roslaunch>
  <node pkg=”turtlesim” node=”turtlesim_node” required=”true” />
  <node pkg=”turtlesim” node=”turtle_teleop_key” output=”screen” />
</roslaunch>
```

Execute: rosparam

- Command line tools for setting and getting param
- Absolute parameters: /node/param
- Local parameters: ~param
- YAML syntax

- rosparam list
- rosparam set /foo "['1', 1, 1.0]"

- rosrun camera1394 camera1394_node __video_mode=”640x480_mono8”

Inspect: rosnode, rostopic, rosservice

- Lists nodes/topics/services and provides information on their states

- rosnode list
- rostopic echo /turtle1/pose
- rostopic pub -1 /text_listener std_msgs/String –"Hello World"
- rostopic hz /camera/image_raw
- rosservice call /kill

Debug: rostest

- Executes unit test on ROS node
  - C++: gtest, Python: unittest
  - Manifest.xml: <depend package=”rostest” />
  - CmakeLists.txt: rosbuild_add_rostest(test/mynode.test)
  - ROSLaunch: <test test-name=”test_mynode” pkg=”mypkg” type=”mynode.test” />
- rostest launch/test_mynode.launch

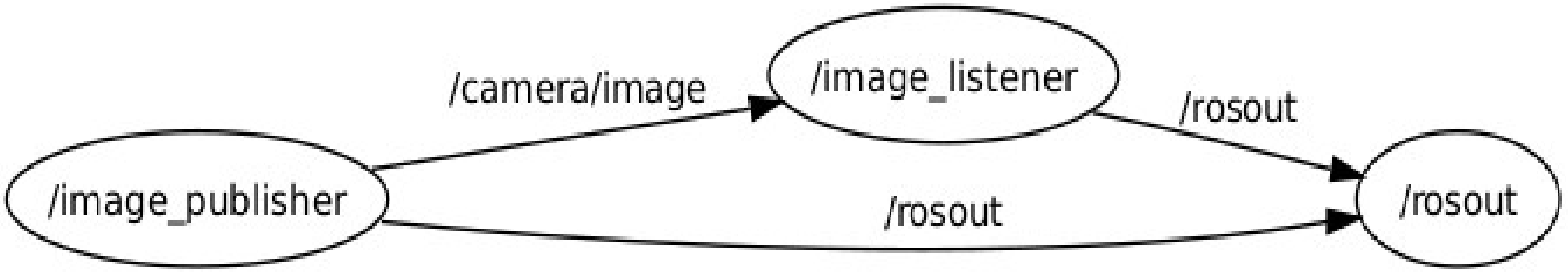
Debug: rostest (cont.)

```
#!/usr/bin/env python
PKG = 'mypkg'
import roslib; roslib.load_manifest(PKG)

import sys
import unittest

## A sample python unit test
class TestBareBones(unittest.TestCase):
    ## test 1 == 1
    def test_one_equals_one(self):
        self.assertEquals(1, 1, "1!=1")

if __name__ == '__main__':
    import rostest
    rostest.rosrun(PKG, 'test_bare_bones', TestBareBones)
```

Debug: roswtf & rqt_graph

- roswtf: finds trivial mistakes (e.g. ROS node not responding, missing publisher, etc...)

- rqt_graph: visualize nodes & messages



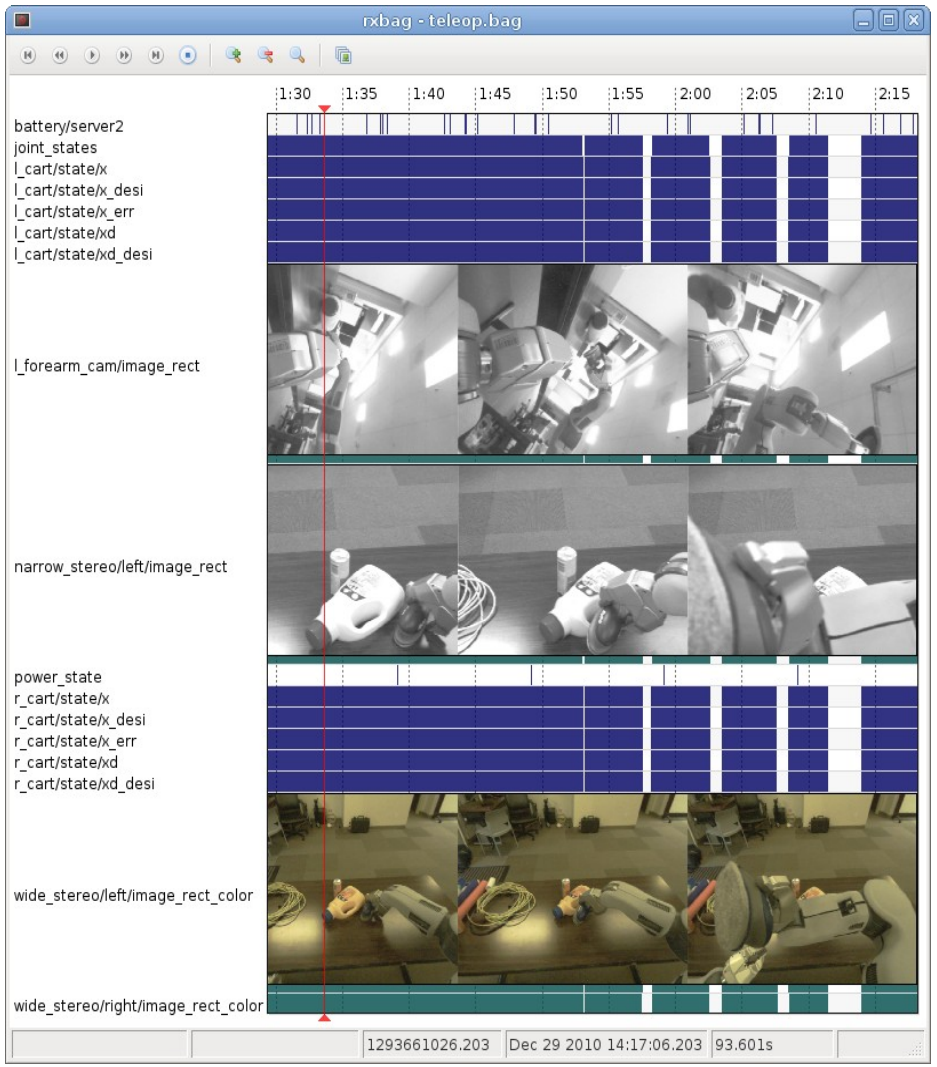
Log & Analyze: rosbag

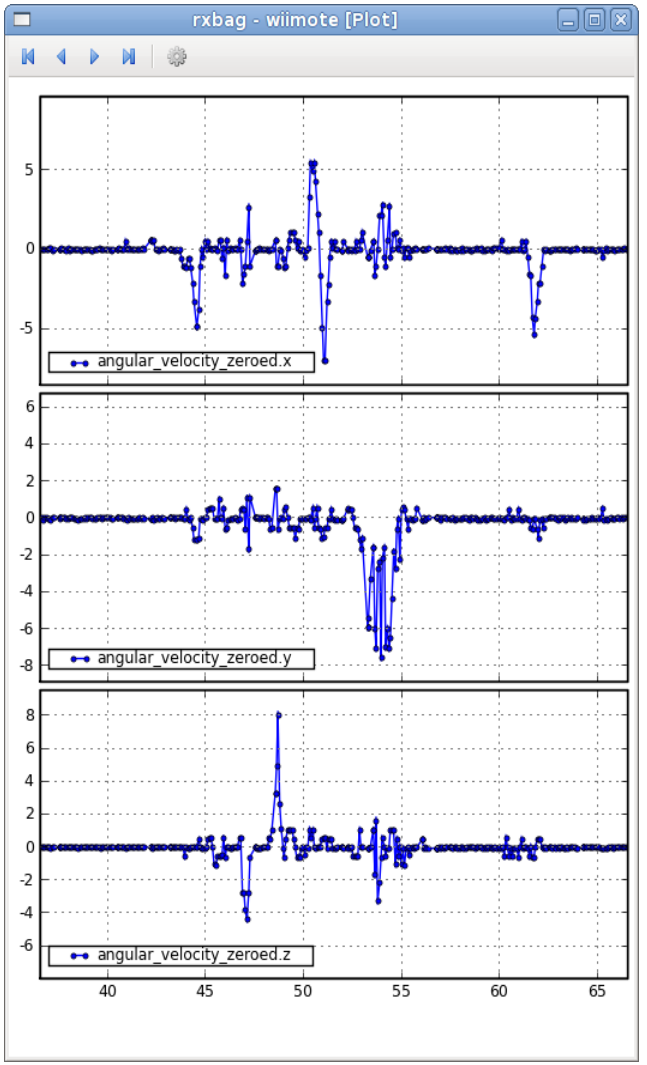
- Records and plays back sets of messages

- rosbag record -a
- rosbag record rosout tf turtle1/pose
- rosbag play -r 1.5 -s 30 -l yesterday.bag
- rosbag compress *.bag
- rosbag reindex *.bag

Log & Analyze: rqt_bag

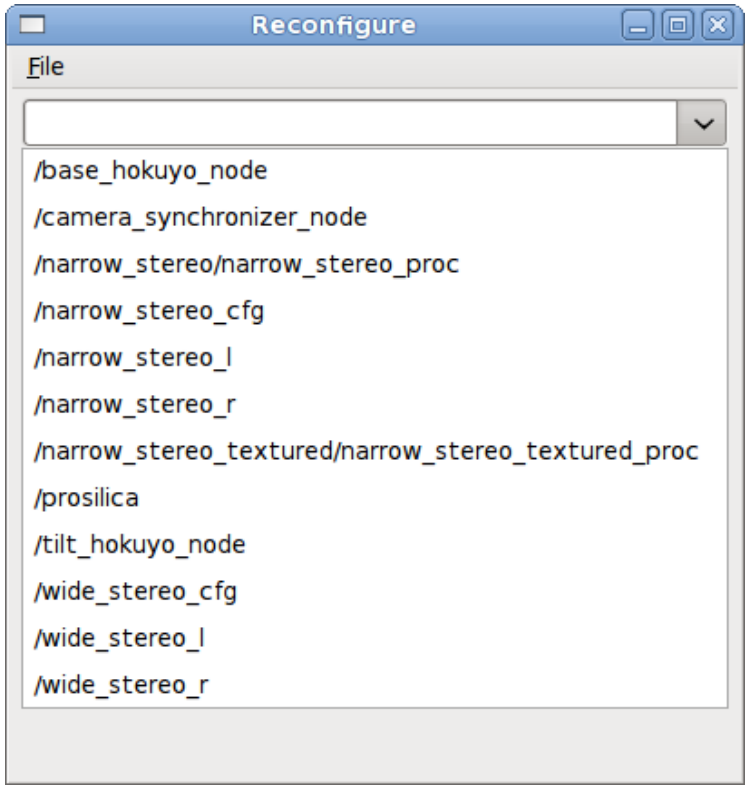
- GUI for visualizing rosbag content

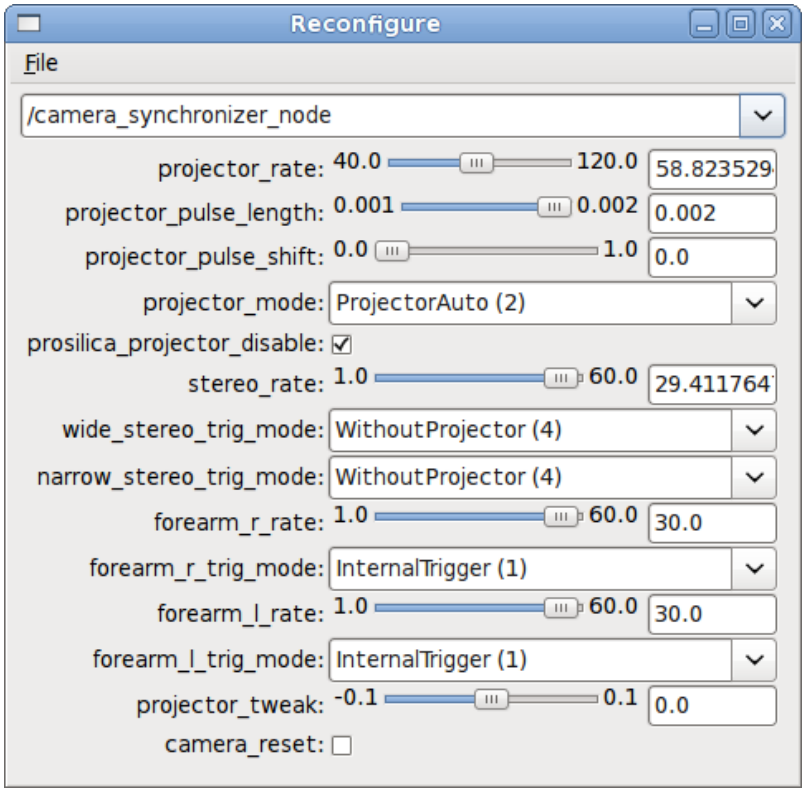




Tool: dynamic_reconfigure

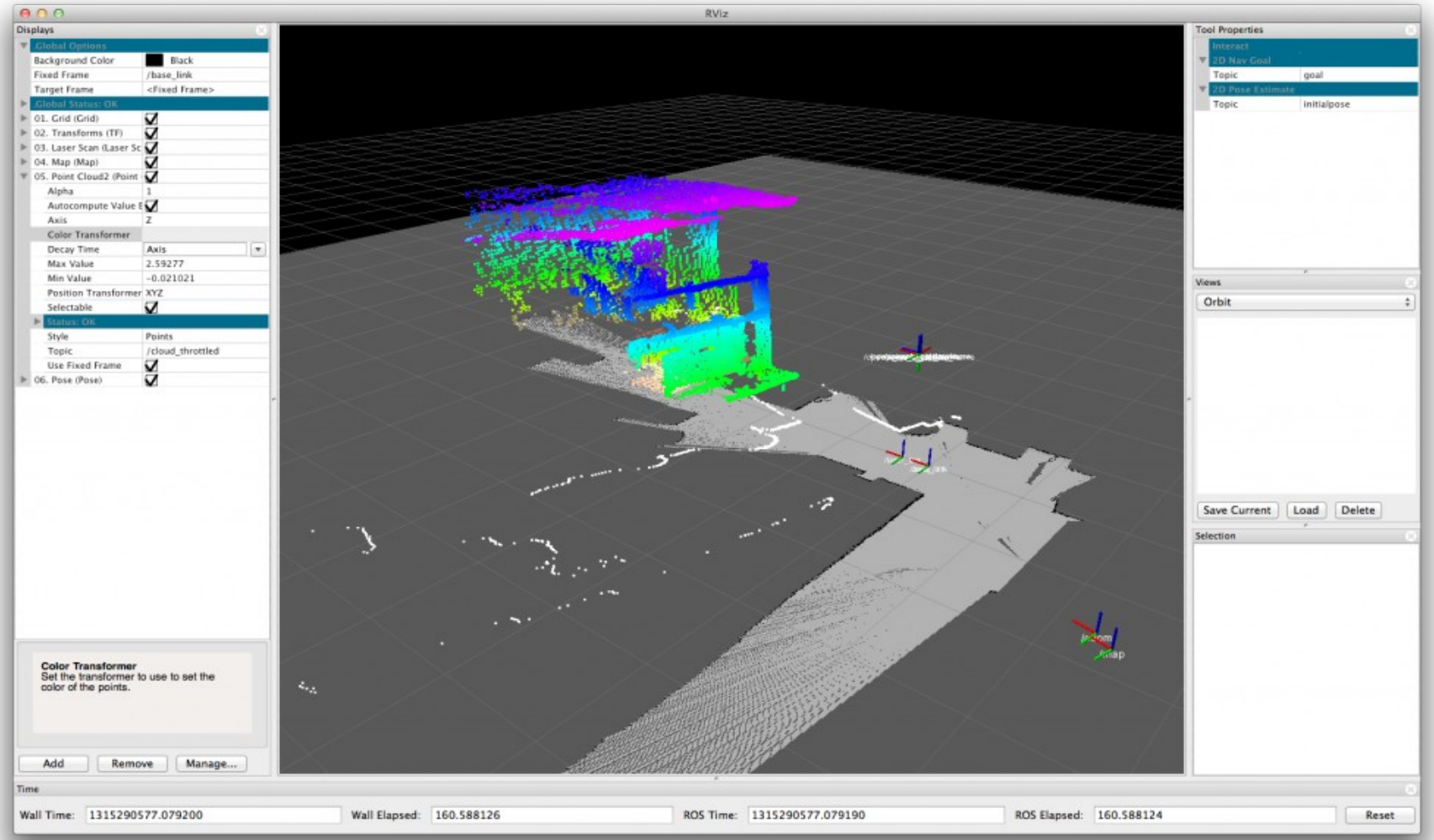
- Changes parameters dynamically in runtime
  - NOT the same as (static) ROS parameters!!!
- rosrun dynamic_reconfigure reconfigure_gui





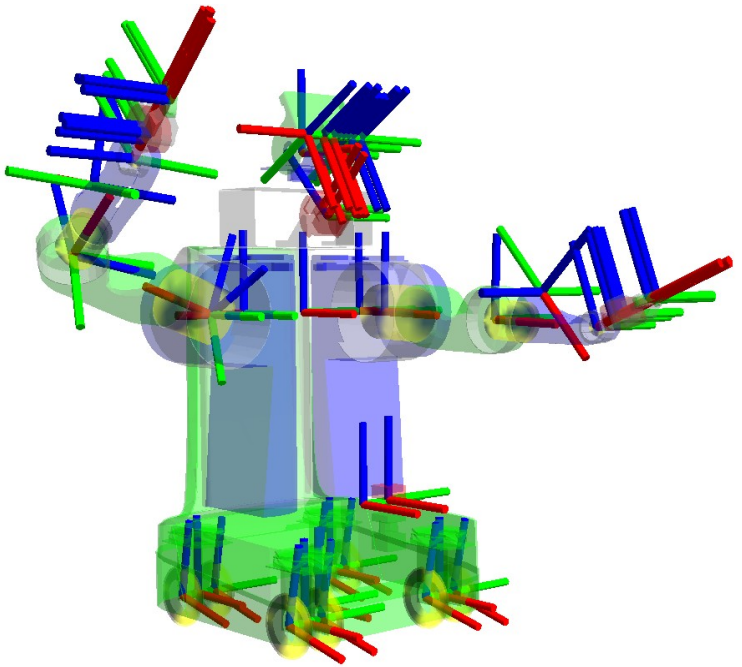
Tool: rviz

- Fully-featured 3D visualization environment



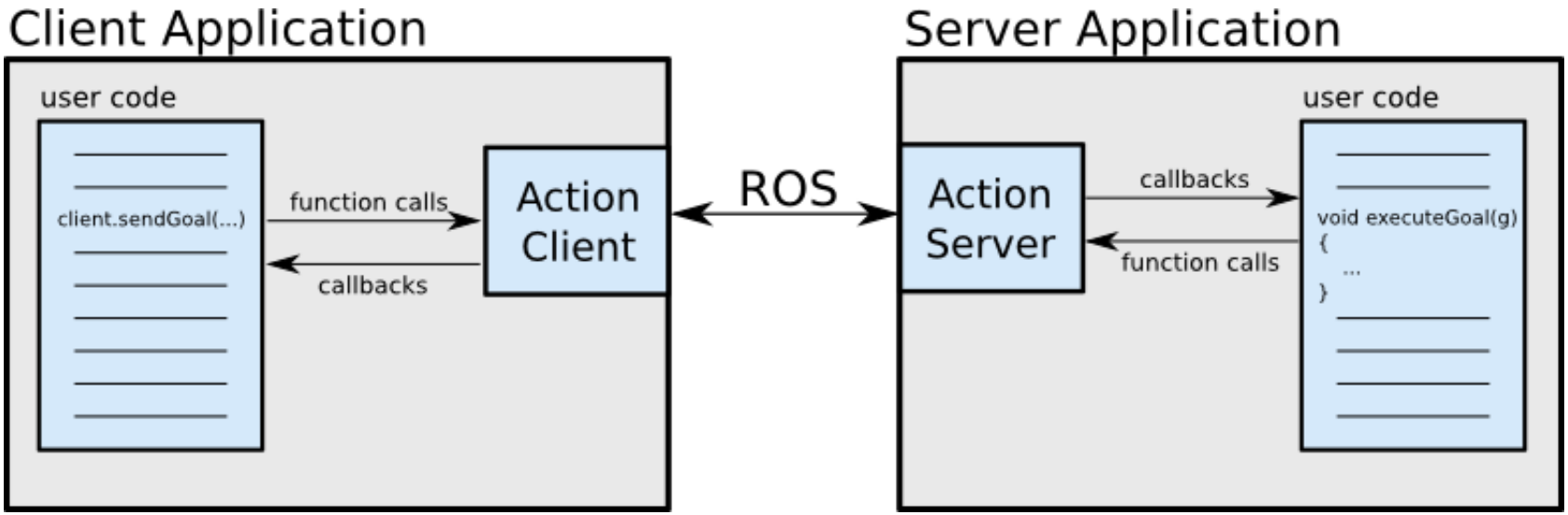
Tool: tf

- Abstraction & manipulation of multiple coordinate frames
  - (Timed) conversion between different frames
  - Distributed broadcaster/listener model



Tool: actionlib

- Lengthy / complex /multi-step services
  - Goal: desired end-result
  - Feedback: incremental progress towards goal
  - Result: feedback upon completion of goal



Questions?

- www.ros.org/wiki/Documentation?action=AttachFile&do=get&target=ROScheatsheet.pdf
- www.ros.org/browse/list.php
- answers.ros.org
- planet.ros.org